Space Weather Technical Forecast

Issued on Sunday, 31 December 2023 at 13:11 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: Chance of M-flares. Slight chance G1-Minor storms from coronal hole fast wind onset day 2 (1st Jan).

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Low with occasional C-class flares, including a C9.6 at 31/0817 and a C8.2 at 31/0912 UTC from a new region that has rotated onto the east limb. The three numbered sunspots on the disc remained small and simple, with either a stable or declining trend. The new region is too close to the limb to accurately assess, but currently appears small, though comprised of a north-south aligned polarity sitting with a single penumbra with a likely delta spot configuration. A further small new region has also recently emerged on the northwest disc.

There were several CME's observed through the period, with a number being analysed as likely missing Earth. This included a couple of filament eruptions off the northwest and southeast. However, the most recent filament eruption CME off the northwest, at 31/1030UTC, is awaiting further imagery for analysis. A further weak CME off the south of the disc was identified as likely coming from a subtle corona reconfiguration around 31/0300 UTC. While relatively slow, faint, and mainly southward directed, a glancing impact cannot be ruled out and analysis is still ongoing.

Solar Wind / Geomagnetic Activity: Background wind speeds were observed with a declining trend, from around 350 km/s to bear 300 km/s. Density was generally around or below average. Interplanetary Magnetic Field (IMF), Bt, was generally weak between 0-8nT. The north-south component, Bz, was mainly positive (northward) peaking +5nT, until 31/0215 UTC, then mainly negative (southward) reaching a minimum of -4nT. Phi angle was negative (towards the Sun). Geomagnetic activity remained Quiet (Kp 0-1).

Energetic Particles / Solar Radiation: GOES16 high energy (greater than 10MeV) proton flux was at background. GOES16 high energy (greater than 2MeV) electron flux ranged was mainly at background. The 24-hour fluence was below Active throughout. The 31/0000 UTC observation was 5.34e6 integrated pfu.

Four-Day Space Weather Forecast Summary

Solar Activity: Low to Moderate activity is expected, with a chance of isolated M-flares due to the potential for a returning cluster of sunspots in the east that likely includes ex-AR3514.

Solar Wind / Geomagnetic Activity: There are couple of weak, potentially glancing CMEs that may have a very minor influence later in the period. This includes a CME from the southwest filament eruption on 30 Dec which is most likely to miss, passing on day 3 (02 Jan). It also includes the slow and faint CME from the C2.6 flare of AR3534 on 30 Dec and the faint corona sourced CME on 31 Dec, which may combine to give a weak glance either late day 4 or just beyond the forecast period on day 5 (03-04 Jan). Otherwise the initial slow wind with background speeds is likely to become elevated to around 550km/s on day 2 (01 Jan) due to the arrival of the fast wind of CH86/-. These winds persisting day 3 (02 Jan), before easing day 4 (03 Jan). Mainly Quiet geomagnetic activity is expected day 1 (31 Dec) becoming Unsettled with a chance of Active intervals and a slight chance of G1 Minor storms day 3 (01 Jan), before easing

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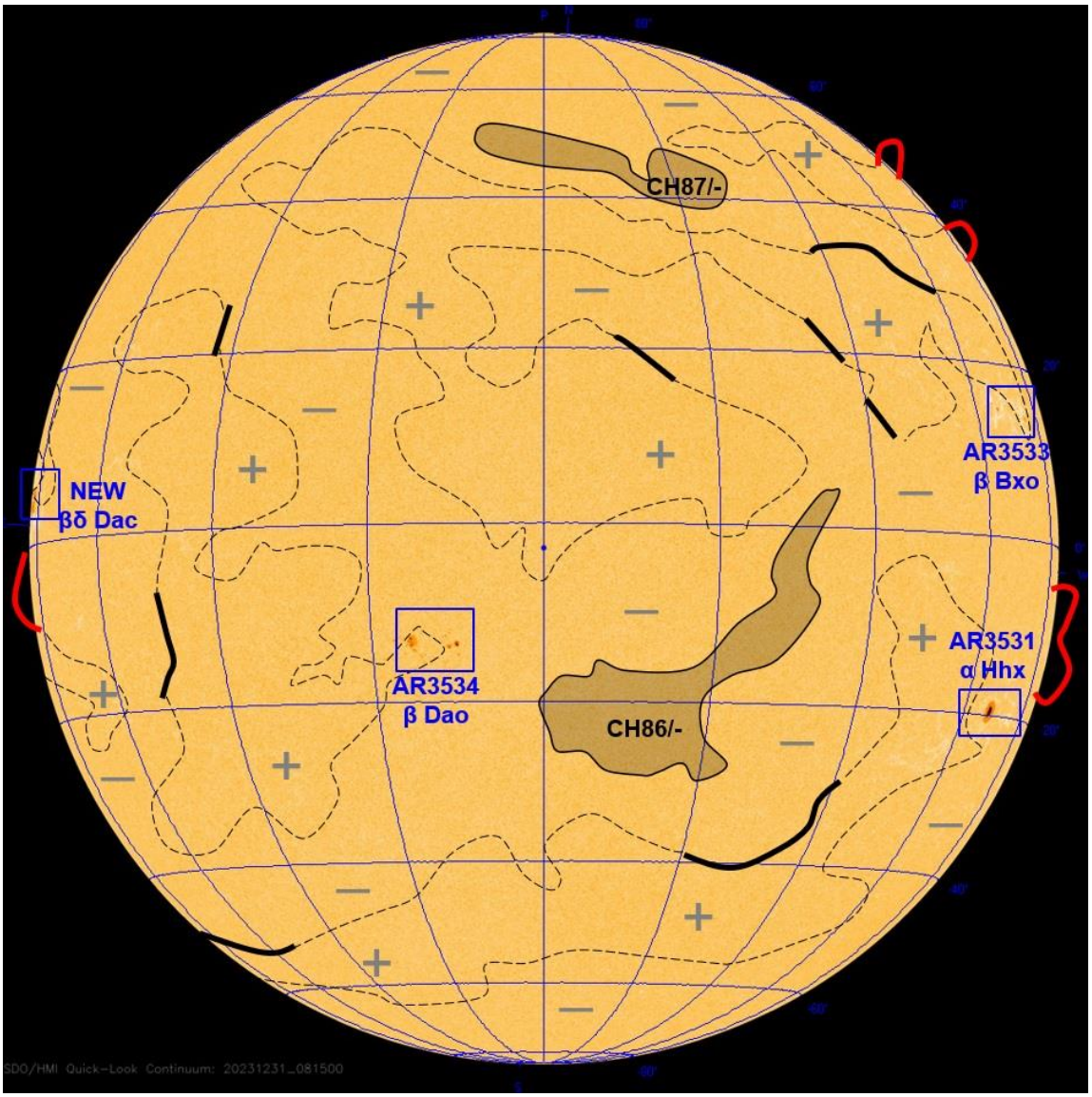
to Quiet with Unsettled intervals day 3 (02 Jan), with a slight chance of Active spells from any CME glances that occur.

Energetic Particles / Solar Radiation: GOES16 high energy proton flux is expected to remain at background levels. GOES16 high energy electron flux is likely to remain at background, but is expected to reach Moderate levels, with a chance of reaching High at diurnal peaks, from day 3 (2nd Jan). The associated 24 hour fluence is expected to remain below Active through the period, but with a rising trend by the end of the period.

Figure 1. Solar Analysis Valid 31/0800 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

There are couple of weak, potentially glancing CMEs that may have a very minor influence later in the period. The first is a filament eruption off the southeast disc on 30 Dec. This is expected to miss but does have a very slight chance of glancing Earth early on day 3 (02 Jan). The second is from a C2.6 flare from AR3534 which followed the filament. This is low confidence, due to being faint and slow, but may give a very slight glance late on day 4 or early day 5 (03-04 Jan). A further CME was also observed on 31 Dec from the southwest disc, due to a corona reconfiguration. This was faint and relatively slow, and generally heading southward, however analysis is still ongoing for any Earth-directed impact.

Slow wind conditions day 1 (31 Dec), with background speeds, are expected to become elevated on day 3 (01 Jan) due to the onset of fast winds from CH86/-, in-line with MOSWOC Enlil. This is a relatively narrower feature compared with the last rotation, at least along its equatorial section, when solar wind speeds of 500-600km/s were observed and geomagnetic activity peaked at Unsettled. Similar speeds are expected on this occasion, however, as a persistent feature there is the chance for Active intervals and slight chance of G1/Minor Storms. Elevated winds are likely to persist day 3 before easing day 4 (02-03 Jane).

Overall mainly Quiet geomagnetic activity is expected day 1 (31 Dec) becoming Unsettled with a chance of Active intervals and a slight chance of G1 Minor storms day 2 (01 Jan), before easing to Quiet with Unsettled intervals day 3 (02 Jan). However, Active intervals remain possible days 3-4 (02-03 Jan) from any very slight CME enhancement that may occur.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	5	20	5	5
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
30/1415	Nil	Filament	SE	715 km/s	Missing (around 02/0600)	Likely missing, but small glance possible
30/2200	Nil	C2.6 AR3534	SE	324 km/s	Weak 04/0200 UTC +/- 12 hours	Low confidence, glancing at most
31/0817	Nil	Corona	SW	440 km/s	Weak 04/0200 UTC +/- 12 hours	Low confidence, mainly missing south

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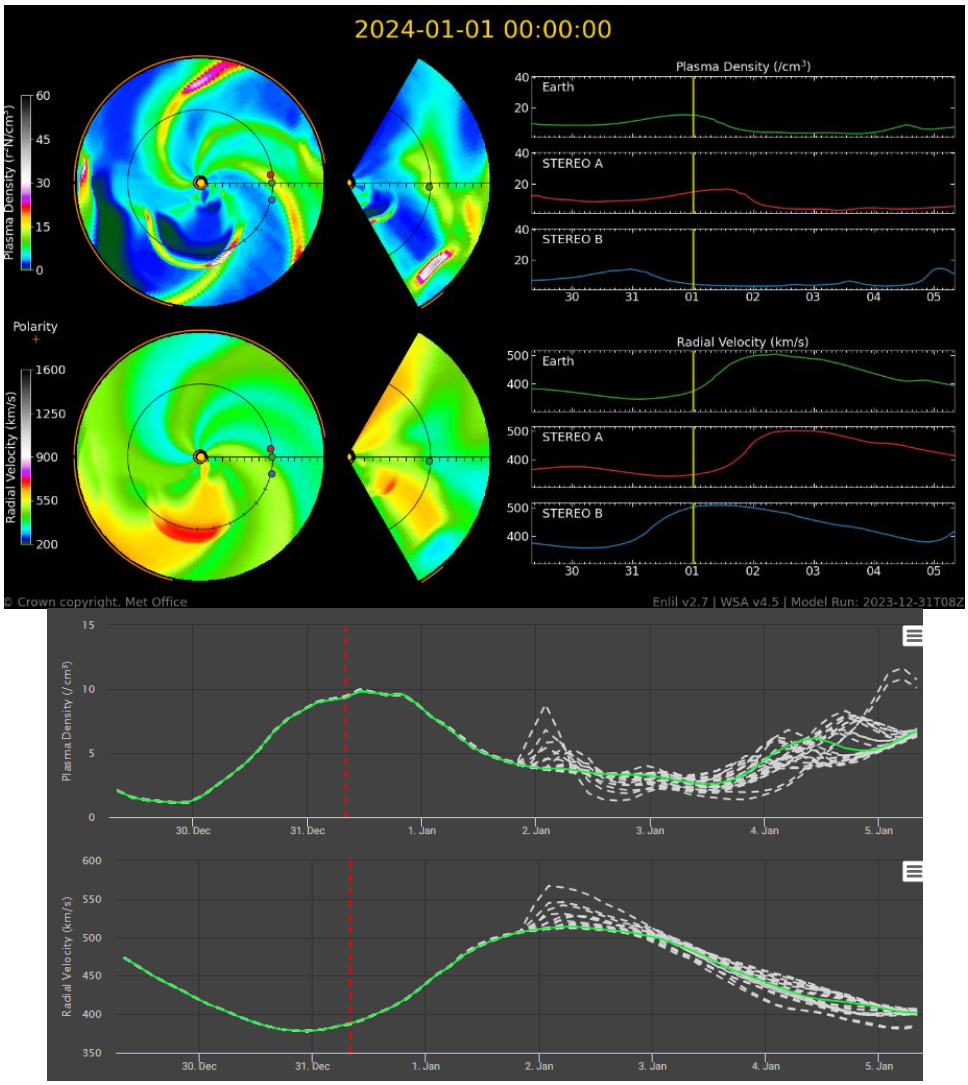
Figure 2a: Enlil and ensemble


2024-01-01 00:00:00
Plasma Density (r-N/cm³)
Polarity
Radial Velocity (km/s)
Plasma Density (/cm³)
Earth
STEREO A
STEREO B
Radial Velocity (km/s)
30 31 01 02 03 04 05
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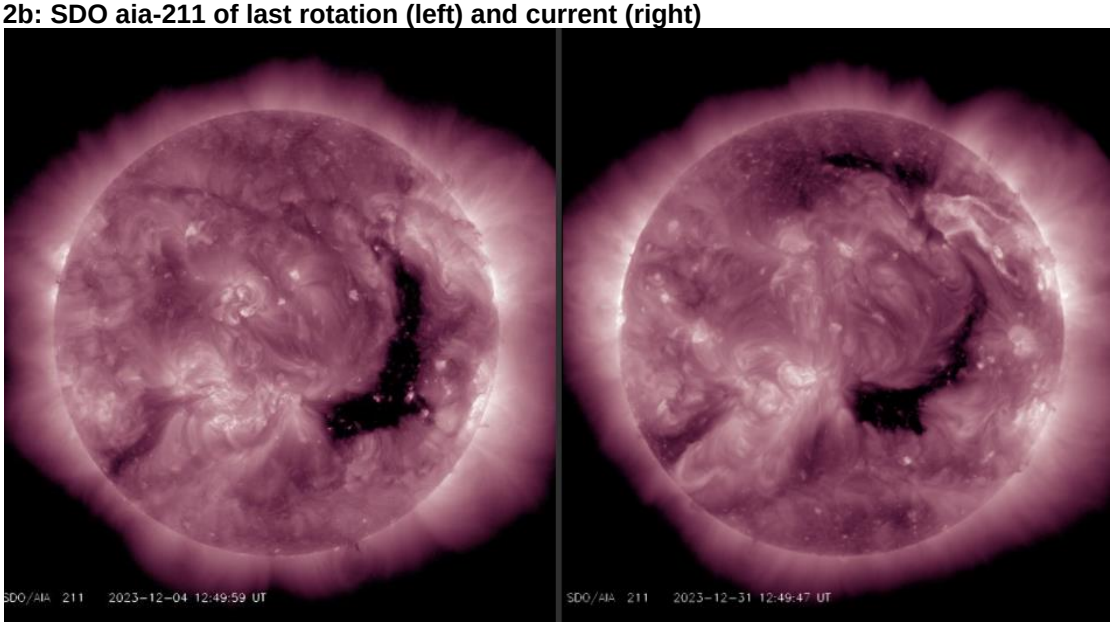
Enlil v2.7 | WSA v4.5 | Model Run: 2023-12-31T08Z
Plasma Density (/cm³)
Radial Velocity (km/s)
30. Dec 31. Dec 1. Jan 2. Jan 3. Jan 4. Jan 5. Jan

Figure 2b: SDO aia-211 of last rotation (left) and current (right)



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Radio Blackouts - X-Ray Flares:

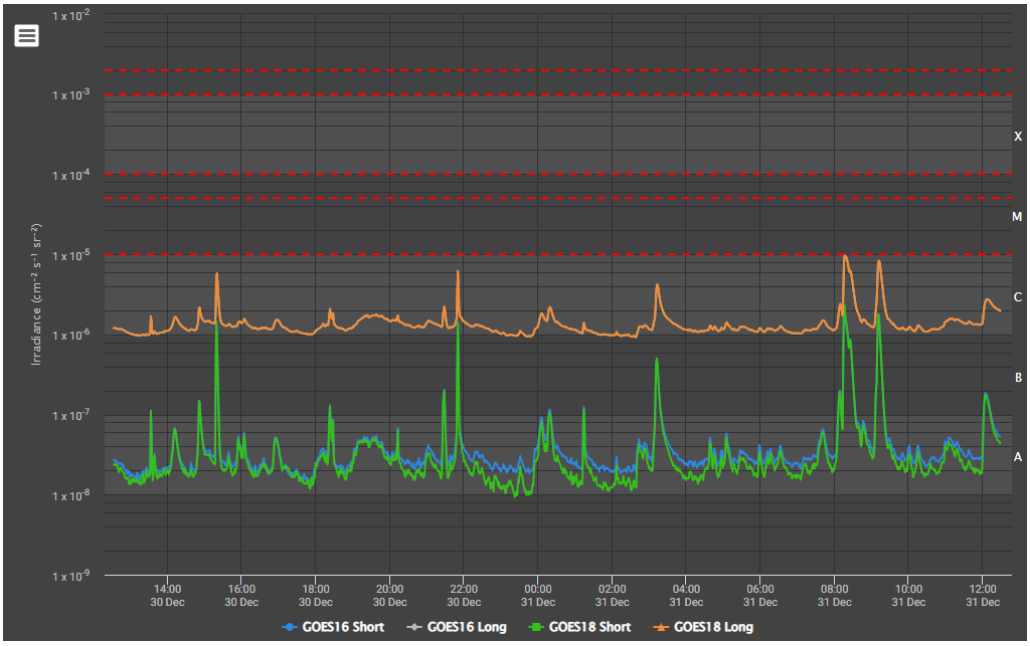
Low to Moderate activity is expected, with the potential for the region or regions rotating onto the disc to give isolated M-flares.

There are five sunspot regions on the Earth-facing disc, three numbered, with the majority of these small, simple and either stable or decaying. The exception is a new region that has recently rotated over the eastern horizon. While small, and difficult to analyse, this appears to be a compact group set within a broader area of plage, with mixed polarities within a single penumbra resulting in a delta-spot configuration. The magnetic looping visible on SDO imagery also suggests either further spots associated with this region, or associated with further regions likely to follow this one.

Far-side seismic products support the arrival of a notable active region or regions in the next 24-48 hours, which would correspond to the return a cluster of sunspots that included ex-AR3514, the source of the last X-flare on 14 Dec. The most recent Mars Perseverance rover image of the Sun, while from just over a week ago (22 Dec), shows this cluster of spots persisting on the far-side. Due to this, a chance of isolated M-flares is maintained through the period.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	No	55	50	45	40
Very Active	R3 to R5 X Class	No	5	5	5	5

Figure 3: GOES-16/18 X-ray Flux



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Solar Radiation Storms - (High Energy Protons):

GOES16 high energy (greater than 10MeV) proton flux is currently expected to remain at background, with only a very slight chance of rising given the occurrence of any significant flares or any filament eruptions from the western disc.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	2	2	2	2
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

High Energy Electrons Event (≥ 2MeV):

High energy electron flux (greater than 2MeV) has seen diurnal fluctuations between background and moderate. Flux is likely to drop out to mainly background with the onset of the fast wind of CH86, before increasing to Moderate from day 3 (02 Jan) with an increasing chance of peaking at High by day 4 (03 Jan).

Electron fluence is expected to remain well below the Active (1e8 integrated pfu) threshold, but likely with a gradually increasing trend from day 3 (02 Jan) as a result of the fast wind onset. This is in line with REFM which is currently giving good guidance.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	1	1	1	10
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

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